

# Prehospital spine immobilization/spinal motion restriction in penetrating trauma: A practice management guideline from the Eastern Association for the Surgery of Trauma (EAST)

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<b>BACKGROUND:</b>	Spine immobilization in trauma has remained an integral part of most emergency medical services protocols despite a lack of evidence for efficacy and concern for associated complications, especially in penetrating trauma patients. We reviewed the published evidence on the topic of prehospital spine immobilization or spinal motion restriction in adult patients with penetrating trauma to structure a practice management guideline.
<b>METHODS:</b>	We conducted a Cochrane style systematic review and meta-analysis and applied Grading of Recommendations, Assessment, Development, and Evaluation methodology to construct recommendations. Qualitative and quantitative analyses were used to evaluate the literature on the critical outcomes of mortality, neurologic deficit, and potentially reversible neurologic deficit.
<b>RESULTS:</b>	A total of 24 studies met inclusion criteria, with qualitative review conducted for all studies. We used five studies for the quantitative review (meta-analysis). No study showed benefit to spine immobilization with regard to mortality and neurologic injury, even for patients with direct neck injury. Increased mortality was associated with spine immobilization, with risk ratio [RR], 2.4 (confidence interval [CI], 1.07–5.41). The rate of neurologic injury or potentially reversible injury was very low, ranging from 0.002 to 0.076 and 0.00034 to 0.055, with no statistically significant difference for neurologic deficit or potentially reversible deficit, RR, 4.16 (CI, 0.56–30.89), and RR, 1.19 (CI, 0.83–1.70), although the point estimates favored no immobilization.
<b>CONCLUSION:</b>	Spine immobilization in penetrating trauma is associated with increased mortality and has not been shown to have a beneficial effect on mitigating neurologic deficits, even potentially reversible neurologic deficits. We recommend that spine immobilization not be used routinely for adult patients with penetrating trauma. ( <i>J Trauma Acute Care Surg.</i> 2018;84: 736–744. Copyright © 2017 Wolters Kluwer Health, Inc. All rights reserved.)
<b>LEVEL OF EVIDENCE:</b>	Systematic review with meta-analysis study, level III.
<b>KEY WORDS:</b>	Guidelines; penetrating trauma; spine immobilization; spinal motion restriction.

Spine immobilization in trauma has remained an integral part of most emergency medical services (EMS) protocols despite a lack of evidence for efficacy and concern for associated complications, especially in penetrating trauma patients. Several studies have shown that, even with proper application, functional immobilization is not actually achieved, prompting an impending change in terminology to “spinal motion restriction” and further pushing the risk/benefit ratio away from recommending the use of cervical spine collars and longboards.<sup>1–5</sup>

There is an increasing call to end the routine use of spine immobilization in patients who would not benefit given the

associated risks related to local pressure injury, increased intracranial pressure, covering penetrating wounds leading to missed injury, and decreasing or delaying the success of life-saving procedures such as endotracheal intubation, particularly in patients who are victims of penetrating trauma.<sup>6–12</sup> For instance, one study assessing patterns of error that lead to trauma mortality cites a 16% failure to secure an airway, which is known to be more difficult in immobilized patients.<sup>13</sup> Aside from the potential complications, we know that most penetrating injuries to the spine represent complete injury that will not be modified by prehospital immobilization.<sup>13–16</sup> Even the injuries deemed unstable and requiring operative fixation are not

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helped by immobilization with cervical collar or spine board since these methods are not particularly effective. A recent cost-utility analysis reinforced this knowledge and showed that not only is spine immobilization not cost-effective, it does not change the outcome for these patients.<sup>14</sup>

Despite evidence that prehospital spine immobilization is not advantageous, and may indeed be harmful, a recent study examining EMS providers and emergency department personnel attitudes and knowledge about the topic revealed that most of this evidence is not known, although attitudes and practice about immobilization varied the most depending on the priority the provider placed on time to definitive care.<sup>15</sup> Other groups have written guidelines on this topic<sup>16,17</sup>; however, none have used the robust Grading of Recommendations, Assessment, Development, and Evaluation (GRADE) methodology or performed a meta-analysis.

Based on data, many large, regional systems have already eliminated the use of cervical collars or spine boards in penetrating trauma.<sup>18</sup> We sought to review the published evidence on the topic of prehospital spine immobilization or spinal motion restriction in patients with penetrating trauma to structure a guideline with the potential to change practice nationwide and eliminate its use in this patient population.

## METHODS

### Objectives

This guideline was created using the GRADE methodology for guideline creation as required by the Eastern Association for the Surgery of Trauma (EAST).<sup>19</sup> The objective of this guideline is to evaluate whether nonoperative spine immobilization of any type is beneficial or harmful in penetrating trauma patients. The population (P), intervention (I), comparator (C), and outcome (O) (PICO) questions are defined below:

PICO Question 1: In adult penetrating trauma patients, does spine immobilization versus no spine immobilization decrease mortality?

PICO Question 2: In adult penetrating trauma patients, does spine immobilization versus no spine immobilization decrease the incidence of neurologic deficit or the incidence of potentially reversible deficit?

### Choosing the Outcome

According to GRADE methodology, outcomes were chosen by the team and rated in importance from 1 to 9, with 7 to 9 representing a critical outcome and 4 to 6 representing an important outcome. The votes of each member of the team were considered equally, and then a score was assigned to each outcome based on the collective conclusion. The outcomes considered were mortality, neurologic deficit, potentially reversible neurologic deficit, missed injury, and failed intubation. The outcomes rated as critical included mortality, neurologic deficit, and potentially reversible neurologic deficit. Potentially reversible deficits were defined as neurologic deficits that could possibly be either improved or entirely reversed with definitive spine immobilization. Outcomes considered important were missed injury and failed intubation, each with a score of 6. There were no other outcomes that the team included, and no outcomes rated less than a 6.

## Criteria for Considering Studies for this Review

### Type of Studies

We considered randomized controlled trials, prospective observational or retrospective studies, and case-control studies. Only studies pertaining to the treatment of penetrating trauma patients (gunshot or stab wound) were included.

### Type of Participants

We included studies with adult patients, of either sex, and with no restriction by ethnicity or comorbidities. Because patients as young as 13 are treated as adults in many centers, these patients were included as adults. Since 13 is commonly used as a cutoff point and was a distinct and consistent cutoff in the reviewed literature, this was decided as a reasonable age criteria for inclusion. Studies consisting solely of pediatric patients were excluded, and there were no studies that mixed adult and pediatric population younger than 13 years. Meta-analyses, case reports, letters, and reviews containing no original data or comments were excluded.

### Type of Intervention

We included studies if spine immobilization was studied in comparison with no immobilization. Spine immobilization was defined as cervical collar and/or longboard.

### Type of Outcome Measures

#### Primary Outcome Measure

The three primary outcomes were mortality, neurologic deficit, or potentially reversible neurologic deficit after spine immobilization versus no immobilization after penetrating trauma.

#### Secondary Outcome Measures

Secondary outcomes considered were missed injury and failed intubation; however, all were deemed to be noncritical for decision making in the GRADE framework.

## Search Methods for Identification of Studies

### Electronic Searches

The PRISMA flow diagram for study selection is shown in Figure 1. A professional librarian conducted a systematic search using the PubMed, Embase, and the Cochrane Library databases for studies with publication dates from January 1, 1980 through February 28, 2017. The search used the following medical subject headings (MESH) terms: Penetrat\*[All Fields] AND ("injuries"[Subheading] OR "injuries"[All Fields] OR "trauma"[All Fields] OR "wounds and injuries"[MeSH Terms] OR "wound" OR "wound" OR "injury" OR "wounds and injuries"[All Fields]) AND ("immobilisation"[All Fields] OR "immobilization"[MeSH Terms] OR "immobilization"[All Fields]). We did not restrict by language or country of publication, although all studies retrieved were in English.

We used the "related articles" function to broaden the search and scanned all citations for relevance. In addition, we repeated the search using the term "spinal motion restriction," as this is a newer term to describe the practice. Because this did not yield any studies using this terminology, spine immobilization will remain the language used throughout the rest of this review. Finally, in addition to the electronic search, we hand

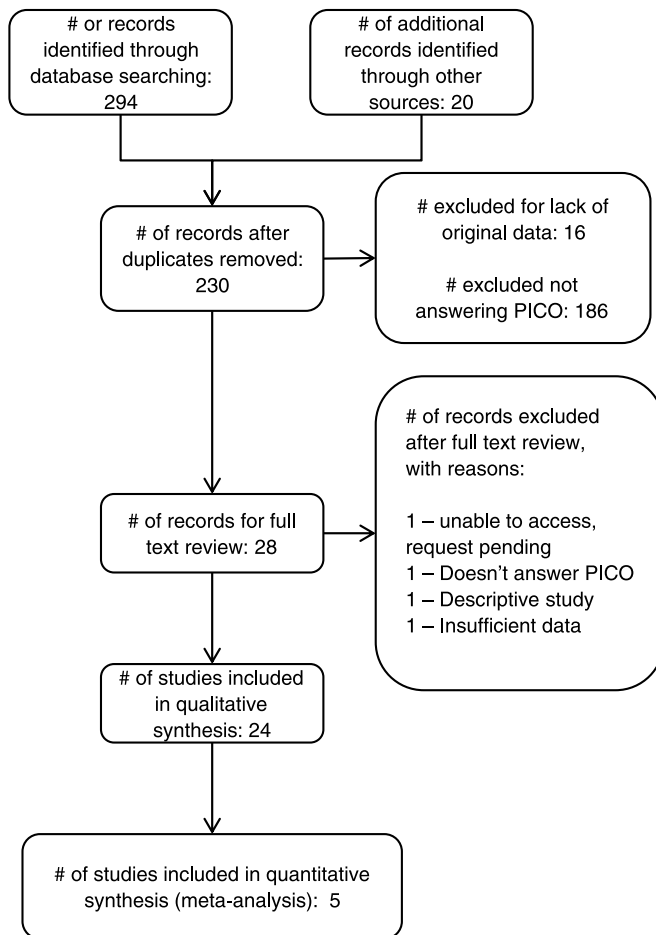


Figure 1. PRISMA diagram.

searched the bibliographies of recent reviews and papers selected for analysis.

## Methods of the Review

### Selection of Studies

After completing the electronic literature search, two independent reviewers screened titles and abstracts, applying inclusion criteria. Any disagreement on inclusion was resolved by consensus of at least three members of the group. The resulting studies then underwent full-text review, again by two independent reviewers, to determine appropriateness for inclusion, and the bibliographies were hand searched for additional articles. Review articles were screened for studies not already included in the electronic search.

### Data Extraction and Management

A subgroup committee appointed by the Chair of the EAST Guidelines Committee was responsible for reading and grading the articles included. All the reviewers are authors of the present manuscript.

Using a form developed by the team, two independent reviewers extracted information from the studies into Microsoft Excel (Microsoft, Redmond, Washington) using double data

entry for accuracy. We then entered these into Review Manager X.6 (RevMan, Cochrane Community, London, UK). Variables collected included information on the authors, study number, country of the study, the methodology of the study, the population, intervention, and the relevant outcome measures.

### Assessment of Methodological Quality of the Included Studies

The articles were evaluated using the GRADE system.<sup>19</sup> The GRADE system describes four levels of quality of evidence. When rating the quality of evidence, decision makers must consider the confidence in the estimate of each effect and whether or not these estimates are likely to be correct. The four levels of quality are *high*, *moderate*, *low*, and *very low*. Recommendations are made based on the GRADE methodology in the following domains: risk of bias, inconsistency, indirectness, imprecision, and publication bias. The data were entered into GRADEpro (Cochrane Community, London, UK) to generate evidence tables.

Strong recommendations are prefaced by the statement “we recommend”, and weak recommendations are prefaced by the statement “we suggest” or “we conditionally recommend,” as per the GRADE methodology. These recommendations are based not only on the quality of the evidence and the risk versus benefit ratio but also on patient values and preferences.

### Measures of Treatment Effect

We reported outcomes as risk ratios (RRs), with associated 95% confidence intervals (CIs) and *p* values. The unit of analysis was individual patients.

### Assessment of Heterogeneity

Potential heterogeneity exists due to population differences, different types of surgery performed, and how patients are defined. We examined these differences across studies to assess the clinical and methodological heterogeneity. For the meta-analysis (see subsection “Data Synthesis (Meta-analysis)” below), we used RevMan to calculate the *Q* statistic, and then the *I*<sup>2</sup> statistic (%) was used to determine the proportion of variation between studies attributable to heterogeneity, and categorized as low (25–49%), moderate (50–74%), or high (74–100%). We also used the  $\chi^2$  test for heterogeneity and examined the CIs for overlap, with decreasing overlap representing increasing heterogeneity.

### Data Synthesis (Meta-analysis)

If heterogeneity was “moderate” to “high,” we examined whether pooling the data was appropriate, and we performed a qualitative narrative summary of results. Based on methodological and clinical similarity, we performed meta-analysis for the outcome for each PICO question. We used the DerSimonian and Laird random effects model method, as our studies did not uniformly share a common effect size, and unknown influential factors could vary across studies (unknown confounders). This allowed us to incorporate both the within-study variability and between-study variability, along a distribution of “true” effects, which weighs larger and smaller studies more evenly.

## RESULTS

### Search Results

A total of 314 records were identified and screened (Fig. 1). After excluding duplicates, those lacking original data and those not addressing the PICO questions, 28 records underwent full-text review. After further exclusions, a total of 24 studies (Table 1) were included in qualitative synthesis, with five of these also included in the quantitative synthesis (meta-analysis).<sup>20-42</sup>

### Qualitative Analysis

Qualitative analysis was performed for the outcomes of mortality, neurologic deficit, potentially reversible neurologic deficit, missed injury, and failed intubation. No study showed benefit to spine immobilization with regard to mortality and neurologic injury, even for patients with direct neck injury. The rate of neurologic injury was generally very low whether patients had spine immobilization or not, with the incidence overall ranging from approximately 2 of 1000 to 76 of 1000 for all comers. Predictably, incidence was much higher in studies selecting for populations with a higher risk of neurologic injury, with an incidence of 136 of 1000 to 204 of 1000 in studies specifically targeting patients with injuries to the head and neck. One study only included patients with neurologic injury. Despite varying rates of injury, the proportion of potentially reversible neurologic injury was consistently very low across all of the

**TABLE 1.** Studies Included in Qualitative and/or Quantitative Synthesis

Author/s	Included Studies				
	Year	Country	Type	Mean Age	Total N
Arishita et al. <sup>20</sup>	1989	US	Retrospective	Adult	296
Aryan et al. <sup>21</sup>	2005	US	Retrospective	15.6 ± 2.7	60
Barkana et al. <sup>22</sup>	2000	Israel	Retrospective	Adult	44
Beatty et al. <sup>23</sup>	2014	US	Retrospective	25	144
Brown et al. <sup>24</sup>	2009	US, inst	Retrospective	28 ± 11	357
Brown et al. <sup>24</sup>	2009	US, NTDB	Retrospective	30 ± 13	75210
Connell et al. <sup>25</sup>	2003	Scotland	Retrospective		1929
Cornwell et al. <sup>26</sup>	2001	US	Retrospective	Adult	1000
DuBose et al. <sup>27</sup>	2009	US	Retrospective	Adult	4204
Harrop et al. <sup>28</sup>	2001	US	Retrospective	38	1904
Haut et al. <sup>29</sup>	2010	US	Retrospective	31.4 ± 13.3	45284
Kaups and Davis <sup>30</sup>	1998	US	Retrospective	28	215
Kennedy et al. <sup>31</sup>	1994	US	Retrospective	Adult	266
Klein et al. <sup>32</sup>	2005	US	Retrospective	Adult	2450
Kupcha et al. <sup>33</sup>	1990	US	Retrospective	Adult	28
Lanoix et al. <sup>34</sup>	2000	US	Retrospective	Adult	174
Lustenberger et al. <sup>35</sup>	2011	US	Retrospective	30.7 ± 12.4	1069
Medzon et al. <sup>36</sup>	2005	US	Retrospective	Adult	81
Ramasamy et al. <sup>37</sup>	2009	UK	Retrospective	Adult	49
Rhee et al. <sup>38</sup>	2006	US	Retrospective	Adult	19856
Schubl et al. <sup>39</sup>	2016	US	Retrospective	Adult	156
Syre et al. <sup>40</sup>	2013	US	Retrospective	24.5	10
Vanderlan et al._mortality <sup>41</sup>	2009	US	Retrospective	Adult	107
Vanderlan et al._neuro <sup>42</sup>	2009	US	Retrospective	29	196
Total					155089

**TABLE 2.** Event Rates for Studies Reporting Neurologic Outcomes

Author	Total N	Proportion with Neuro Deficit	Proportion with Reversible Deficit
Arishita et al. <sup>20</sup>	296	0.014	0.014
Barkana et al. <sup>22</sup>	44	0.204	0
Brown et al. <sup>24</sup>	357	0.048	0
Brown et al. <sup>24</sup>	75210	0.014	0.00034
Connell et al. <sup>25</sup>	1929	0.006	0
Cornwell et al. <sup>26</sup>	1000	0.002	0.002
DuBose et al. <sup>27</sup>	4204	0.036	0
Haut et al. <sup>29</sup>	45284	0.016	0.014
Kaups and Davis <sup>30</sup>	215	0	0
Kennedy et al. <sup>31</sup>	266	0	0
Klein et al. <sup>32</sup>	2450	0.055	0.055
Kupcha et al. <sup>33</sup>	28	1*	0.071
Lustenberger et al. <sup>35</sup>	1069	0.004	0
Medzon et al. <sup>36</sup>	81	0.136	0.012
Ramasamy et al. <sup>37</sup>	49	0.061	0
Rhee et al. <sup>38</sup>	19856	0.006	0
Schubl et al. <sup>39</sup>	156	0.006	0.006
Vanderlan et al._neuro <sup>42</sup>	196	0.076	0
Total	152690		

\* The study only selected patients with neurologic injury.

studies reporting neurologic outcomes, ranging from 3.4 of 10,000 to 550 of 10,000 (Table 2). Schubl et al.,<sup>39</sup> who examined patients with firearm injury to the head and/or neck, concluded that cervical spine immobilization might be of value; however, of the two patients with unstable fractures, while one of them developed transient neurologic symptoms, it was later in the course and would not have been affected by prehospital care.

Arishita et al.<sup>20</sup> noted that intubation takes two EMS providers 5.64 + 1.49 minutes to perform correctly in the setting of immobilization. Kaups and Davis<sup>30</sup> similarly noted the association with spine immobilization and intubation, where multiple intubation attempts resulted with greater frequency in immobilized patients: 49 attempts in 34 patients versus 5 attempts in 4 patients who were not immobilized.

Some large database studies have suggested that spine immobilization in penetrating trauma may not be beneficial and may, in fact, be potentially harmful. Haut et al.<sup>29</sup> in a National Trauma Data Bank study showed that the number needed to treat to potentially benefit just one penetrating trauma patient is 1032. In contrast, the number needed to treat to potentially contribute to one death was only 66. Cornwell et al.<sup>26</sup> looked at 1000 patients in Maryland with torso gunshot wounds and found that only two patients required operative vertebral column stabilization but that given the almost uniformly complete injury sustained with this mechanism, “thoracolumbar immobilization is almost never beneficial in patients with torso GSW [gunshot wounds]” and “the role of formal thoracolumbar immobilization should be reexamined.”<sup>26</sup>

A recent study by Beatty et al. of 144 patients with GSW to the neck closely examined progression of injury. Complete spinal cord injury was noted in 28 patients. Fourteen patients

underwent intervention for incomplete injury; of these, two had measured deterioration during their course, but this was noted to be from compression from the bullet rather than concern over movement of the neck, and both had marked recovery after decompression. Three of the patients who underwent operative stabilization with incomplete injury improved by one level. There were no patients with deterioration or improvement attributed to nonoperative immobilization.<sup>23</sup> Another recent study by Syre et al.<sup>40</sup> examined patients with atlanto-occipital injury. Only one of these patients presented with unstable injury, and the two patients with deficits had delayed presentation after several days that would not have been affected by prehospital spine immobilization.

These studies all purportedly exclude blunt trauma, although minor blunt trauma may have been present. Across these studies, there is the suggestion that minor blunt trauma can be exempted from immobilization as well; but none of the studies in this review examined this question closely enough to draw any conclusion.

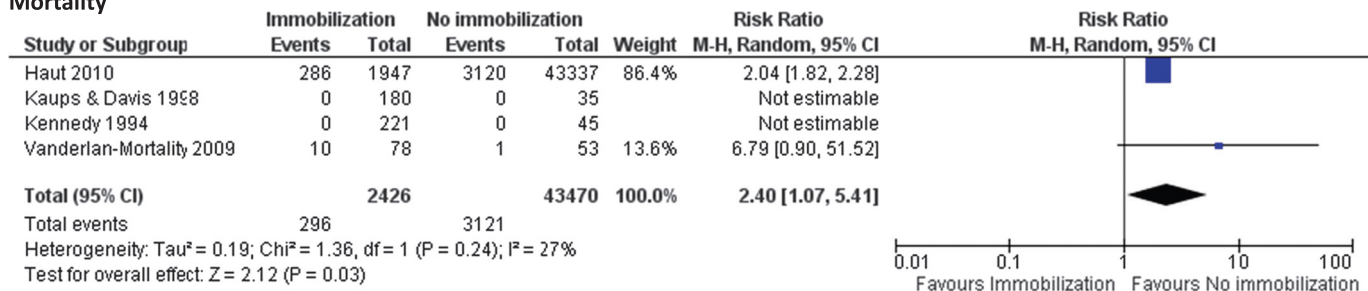
### Quantitative Analysis

Quantitative analysis was performed for the outcomes of mortality, neurologic deficit, and potentially reversible neurologic deficit. No benefit to spine immobilization was found with regard to these outcomes. There were insufficient data to perform a meta-analysis with regard to failed intubation or missed injury.

For mortality, only four studies had sufficient data points to complete the meta-analysis.<sup>29-31,41</sup> Because two studies had no mortality in either group, the pooled estimate relied heavily on two studies, but these represented 43,390 patients, with a relative risk of 2.4 (CI, 1.07-5.41) for increased mortality associated with spine immobilization, shown in Figure 2A. Because one study contributed the vast number of events, thus being disproportionately represented, a random effects model was used to account for variation in study size and relative contribution. Because the point estimates are in the same direction, this is a fair representation of the conclusions of both studies.

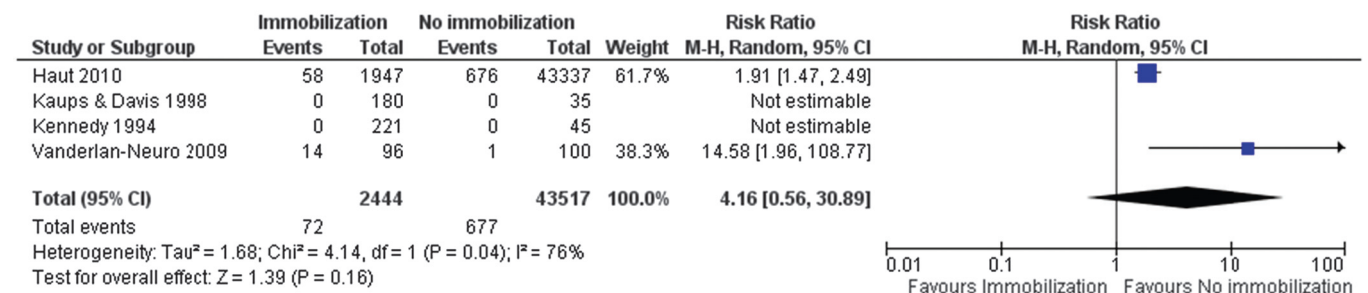
A

#### Mortality



B

#### Neurologic Deficit



C

#### Potentially Reversible Deficit

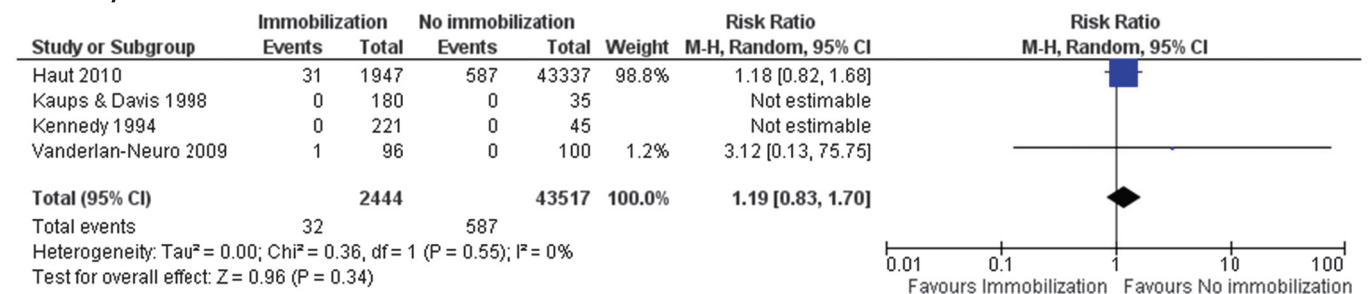


Figure 2. (A-C) Forest plots.

**TABLE 3. Question: Spine Immobilization Versus No Spine Immobilization for Penetrating Trauma**

Quality Assessment		Summary of Findings									
		Study Event Rates (%)			Anticipated Absolute Effects						
Participants (Studies) Follow-up	Risk of Bias	Inconsistency	Indirectness	Imprecision	Publication Bias	Overall Quality of Evidence	With Control	With Spine Immobilization Versus No Spine Immobilization	Relative Effect (95% CI)	Risk with Control	Risk Difference with Spine Immobilization Versus No Spine Immobilization (95% CI)
Mortality (critical outcome)											
45,896 (4 studies)	No serious risk of bias	No serious inconsistency	No serious indirectness	No serious imprecision	Undetected	Moderate* due to large effect	3121/43470 (7.2%)	296/2426 (12.2%)	RR, 2.4 (1.07–5.41)	72 per 1000	101 more per 1000 (from 5 more to 317 more)
Neurologic deficit (critical outcome)											
45961 (4 studies)	No serious risk of bias	No serious inconsistency	No serious indirectness	Serious**	Undetected	Very low**; †, ‡	677/43517 (1.6%)	72/2444 (2.9%)	RR, 4.16 (0.56–30.89)	16 per 1000	49 more per 1000 (from 7 fewer to 465 more)
Potentially reversible deficit (critical outcome)											
45961 (4 studies)	No serious risk of bias	Serious§	No serious indirectness	Serious¶	Undetected	Very low§, ¶, ††	587/43517 (1.3%)	32/2444 (1.3%)	RR, 1.19 (0.83–1.7)	13 per 1000	3 more per 1000 (from 2 fewer to 9 more)

\*Upgrade due to large effect.

\*\*Wide confidence intervals.

†Patients with deficits more likely to have immobilization.

‡Confounding by indication.

§Variation in definition of potentially reversible.

¶Wide confidence intervals, events rare.

||Effect > 15%.

††Surrogate end point of surgical fixation does not necessarily equate with reversibility.

Adapted from Spine immobilization for penetrating trauma. *Cochrane Database Syst Rev* [Year]. Issue [Issue].

**TABLE 4.** Summary of Findings and Recommendation

Question	Findings and Recommendation
PICO 1	In adult penetrating trauma patients, spine immobilization does not decrease mortality. To the contrary, it is associated with increased mortality.
PICO 2	In adult penetrating trauma patients, spine immobilization does not decrease neurologic deficit or potentially reversible neurologic deficit. We recommend that spine immobilization not be used routinely for adult patients with penetrating trauma.

For neurologic deficits, there were also four studies meeting criteria for inclusion with sufficient data points for the meta-analysis.<sup>29–31,42</sup> There was no statistically significant difference between spine immobilization versus no immobilization, although the point estimate was in favor of no immobilization (RR, 4.16; CI, 0.56–30.89; Fig. 2B). The failure to meet statistical significance is likely due to across-study variability, as the point estimates were quite significant for the unpooled studies (RR, 1.91; CI, 1.47–2.49 and RR, 14.58; CI, 1.96–108.77), and a more conservative random effects model was used. The data were pooled in the setting of a moderate to high  $I^2$  to visually highlight this heterogeneity contributing to lack of statistical significance. Finally, no difference was seen for potentially reversible deficits (Fig. 2C), with RR 1.19 (CI 0.83, 1.70) and minimal heterogeneity across the studies.

### Grading the Evidence

The GRADE evidence table is shown in Table 3. For the outcome of mortality, rated by the group as a critical outcome, the included studies were rated as having no serious risk of bias, and no serious inconsistency, indirectness, or imprecision. No publication bias was detected. In fact, given previous assumptions and protocols endorsing the benefits of spine immobilization, one might expect that these studies would have been at risk for nonpublication for arriving at the opposite conclusion. Given no downgrades in these areas of study quality, and due to a large magnitude of effect, the quality of the evidence was upgraded from the starting point of low for observational studies to moderate. For neurologic deficit, also a critical outcome, included studies were rated as having no serious risk of bias, and no serious inconsistency, indirectness, or publication bias. Due to the wide CIs, however, as well as potential confounding by indication, the evidence was downgraded from the starting point of low for observational studies to very low. For the additional critical outcome of potentially reversible neurologic deficit, there was no serious risk of bias, including publication bias, detected. There was also no serious indirectness noted, but because of inconsistency related to variation in the definition of “potentially reversible” across the studies, and imprecision related to wide CIs and the rareness of the event rate, the evidence for this outcome was also downgraded from the starting point of low for observational studies to very low.

## DISCUSSION

Similar to previous reviews, routine spine immobilization in penetrating trauma is not of benefit and may be harmful. The most striking finding of this systematic review is that mortality is clearly associated with spine immobilization. Some studies suggest that this may be related to the injuries themselves, while others suggest that immobilization hampers the

ability of providers to care appropriately for the patient as it can obscure injury, make necessary life-saving procedures more difficult, and delay transportation to definitive surgical care at a trauma center.

Importantly, we cannot show that spine immobilization is beneficial with regard to critical outcomes related to neurologic deficits. Although not discussed in this review specifically, multiple studies not done directly on patients, but looking at the mechanics of spine immobilization, demonstrate that the available methods are not effective in eliciting the degree of immobilization that would be necessary to be even theoretically effective.<sup>43,44</sup> Although the level of evidence is low, when one intervention shows no benefit over another and is done solely by tradition, there is a reasonable argument for its removal from standard practice.

All of the studies in this area are observational; there have been no randomized controlled trials of immobilization versus nonimmobilization. Most studies assume spine immobilization was performed since it was the protocol in most areas at the time of the studies, which may not have always been the case. Few of the studies specify the type or extent of immobilization, whether with cervical collar, longboard, or other types of immobilization devices. Further complicating analysis instead of directly comparing interventions, many of the studies only look at projected risk versus benefit by assessing which patients did or did not have any injury. Assumptions vary as to what constitutes “potential benefit,” particularly with regard to “potentially preventable neurologic deficit.” For instance, some studies use surgical fixation as a surrogate end point for reversible neurologic disease, but the studies actually examining this rate demonstrate that surgical fixation may halt or prevent, but not reverse, injury that has already occurred.

## RECOMMENDATION

We recommend that spine immobilization not be used routinely for adult patients with penetrating trauma, as it is associated with increased mortality and has no benefit in preventing neurologic deterioration (Table 4). This strong recommendation is based on the assumption that most patients (although not all) would place a higher value on survival, even with potential neurologic deficits. The strength of the recommendation is based on magnitude of effect, assumption of patient preference, and the favorable risk/benefit profile.

## CONCLUSION

Spine immobilization in adult penetrating trauma patients is associated with increased mortality and has not been shown to have a beneficial effect on mitigating neurologic deficits, even potentially reversible neurologic deficits. We recommend that

spine immobilization not be used routinely for adult patients with penetrating trauma.

#### AUTHORSHIP

C.G.V. and E.R.H. conceptualized the study. C.G.V. and E.R.H. created the PICO questions. C.G.V., L.L., M.F., J.S., and E.R.H. voted regarding the outcomes of interest for these PICO questions. C.G.V. and H.M.S. evaluated the articles independently for secondary outcomes. C.G.V., H.M.S., and ERH performed the literature search, read all of the abstracts, and selected the articles for review, as well as reviewed and summarized the selected articles. C.G.V. and H.M.S. extracted the data from the selected articles. C.G.V. entered the extracted data into the RevMan and GRADEpro programs and evaluated the results for recommendations. C.G.V. and E.R.H. wrote the manuscript. A.R., H.M.S., L.L., J.S., and E.R.H. reviewed this manuscript for methodological content and made critical revisions to the final draft. All authors participated in the critical review of all versions of this paper.

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#### DISCLOSURE

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